Preface

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[1] On 12 October 1998, the Canadian Coast Guard Icebreaker *Des Groseilliers* broke free of the arctic ice pack, ending the yearlong drift of Ice Station SHEBA. During the drift, more that 180 researchers participated in an interdisciplinary measurement program to study the Surface Heat Budget of the Arctic Ocean (SHEBA). Ironically, this research expedition to the frigid Arctic was motivated by the question of global warming. Results from global climate models indicate that the initial impact of greenhouse warming will be greatest in the Arctic and that the warming will be accelerated by ice albedo feedback (IAF) and cloud radiation feedback (CRF) mechanisms that operate in the sea ice cover. Though these feedbacks have been recognized as potentially important, they are not well understood. In particular, detailed measurements of the processes that affect these feedbacks over the annual cycle were lacking. This provided the motivation for the SHEBA project.

[2] SHEBA has two broad goals: to understand the ice albedo and cloud radiation feedbacks and to use this understanding to improve climate models. The positive nature of the ice albedo feedback has been appreciated for over a century. Snow-covered sea ice reflects over 80% of the incident solar irradiance. However, some of the sunlight is absorbed, and the snow and ice eventually warm and melt. As melting proceeds, the surface albedo decreases, allowing more sunlight to be absorbed, thereby accelerating the melt. SHEBA aims to quantify this feedback mechanism, including evaluating the contributions of the individual physical processes that determine the feedback. Less is known about cloud radiation feedback. In winter, the impact of clouds on the surface heat budget is straightforward: Clouds increase the net longwave radiation and warm the surface. The summer situation is more complex. As in winter, clouds increase the net longwave irradiance, but they also reduce the net shortwave irradiance. SHEBA observations showed which effect dominated throughout the year. The CRF mechanism operates through changes in the amount and properties of clouds that result from changes in the surface heat budget. Since the effect of clouds on the surface heat budget depends on the surface albedo, and the effect of the surface on clouds depends on the surface temperature, there is coupling between the CRF and IAF. Analysis of these feedback mechanisms requires the use of climate models. The experimental design for SHEBA links the observation and analysis of processes with the development of enhanced process models that are incorporated into climate models. In this framework, SHEBA aims to determine how changes to the process models, motivated and constrained by observations, affect the feedbacks in the climate model.

[3] The feedback mechanisms are affected by processes and properties in the atmosphere, ice, and ocean. Because of this, an objective of the field program was to acquire a comprehensive, integrated data set over an annual cycle from the top of the atmosphere through the ice down into the upper ocean. Simultaneous measurements were made of the profile properties of the atmosphere, cloud fraction and properties, atmospheric boundary layer, surface radiation fluxes, albedo, snow properties, ice mass balance, ice stress, ocean boundary layer, and thermohaline structure of the upper ocean. Because of the large variability of surface properties, such as ice thickness and snow depth, on spatial scales small compared to atmospheric weather systems, SHEBA measurements were made at multiple sampling sites and in spatial surveys. The objective here was to sample a region large enough to represent the surface ‘‘footprint’’ of a single grid cell in a high-resolution climate model. This footprint, extended vertically from the tropopause to the halocline layer of the Arctic Ocean, constitutes the ‘‘SHEBA column.’’

[4] The 22 papers in this special section represent the breadth of the SHEBA effort. Most of them document important elements of the SHEBA column, including cloud properties, surface heat fluxes, seasonal evolution of albedo, ice dynamics and deformation, solar heating in leads, ocean turbulent fluxes, and ice surface morphology. The papers also demonstrate the commonality of the SHEBA effort; each of them treats processes that affect the surface heat budget, the cloud cover, or other factors that ultimately influence the IAF and CRF mechanisms. The measurements on which these papers are founded were made on the surface, from aircraft, from satellites, and from submarines. They span the observational scales from a single point to an individual floe to an aggregate of floes to the entire Arctic Basin. While many of the papers focus on field observations, some model results are also presented. This reflects the fact that the SHEBA project is continuing. Phase 3, now underway, emphasizes the combined application of the field measurements and models to

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analyze the feedback mechanisms and to improve climate models.

[5] A major legacy of SHEBA is the set of observations that documents the air-sea-ice column over the SHEBA year. These data are available for use by the scientific community, through the Joint Office of Science Support, University Corporation for Atmospheric Research (http://www.joss.ucar.edu/cgi-bin/codiac/projs?SHEBA). The data will be archived for long-term access at the Arctic System Science Data Coordination Center, National Snow and Ice Data Center (http://arcss.colorado.edu).

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